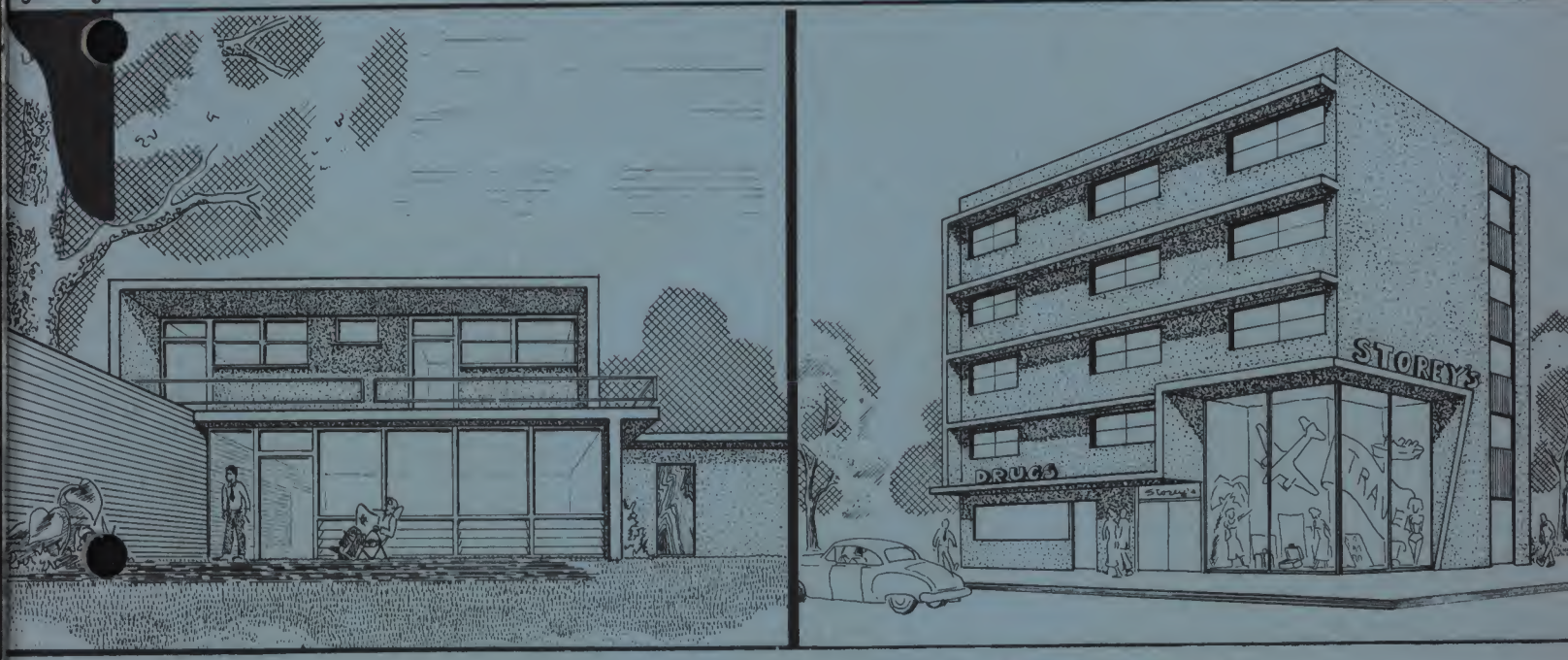
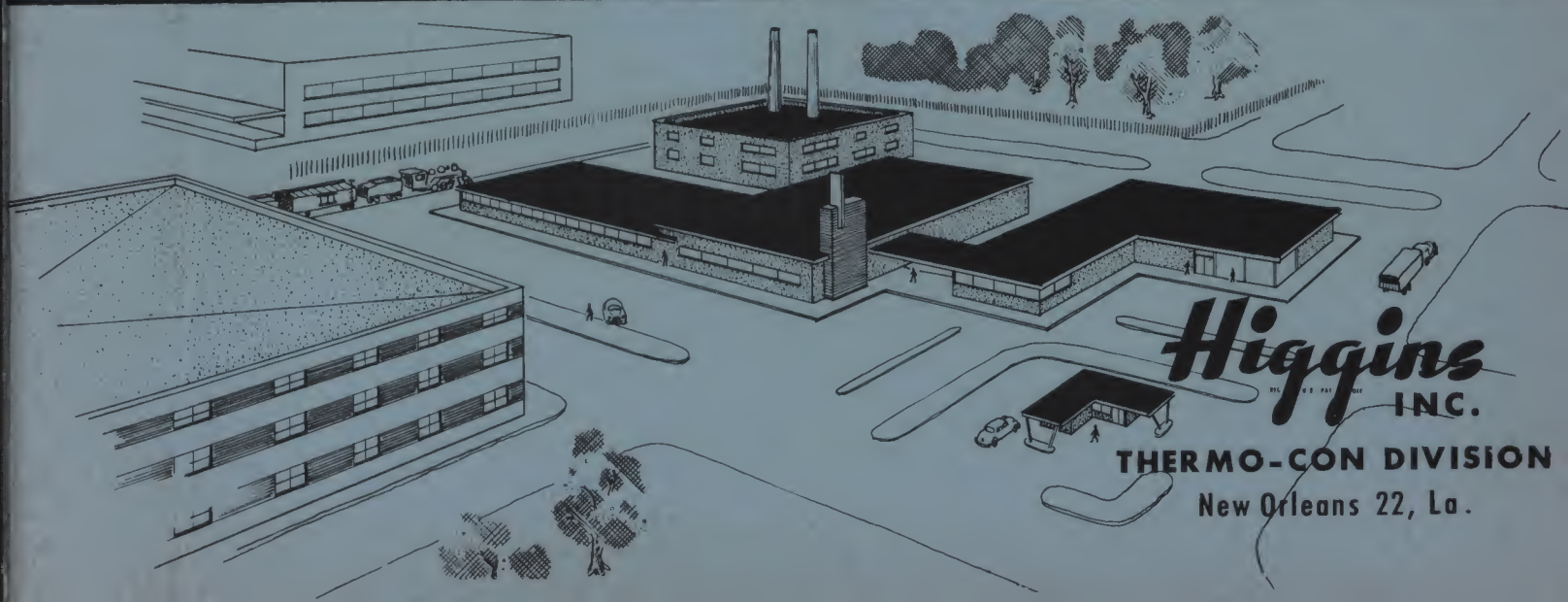
Designing for the

Thermo-Con Cellular Concrete System

Reg. U. S. Pat. Office





Higgins INC.

THERMO-CON DIVISION

New Orleans 22, La.

PREFACE

Thermo-Con cellular concrete is a light-weight building material of constant uniformity and structural properties which is prepared from Portland cement, water and chemicals of mineral origin. It contains no aggregate. The finished material is composed of countless very small and uniformly sized spherical cells, having a density of approximately 45 lbs. per cu. ft., (less than one-third the weight of rock concrete).

Thermo-Con cellular concrete is prepared as a liquid slurry by combining the ingredients in the Thermo-Con generator, a special Higgins-designed and patented machine, built to insure uniformity in all Thermo-Con cellular concrete mixes. Once prepared, the slurry is pumped by the generator into forms where it subsequently rises to more than twice the level of the initial pour.

In tests conducted by Pittsburg Testing Laboratories and witnessed by the Federal Housing Administration, Thermo - Con cellular concrete proved far superior to commonly used masonry materials in transverse bending, racking and impact shock. Albert Kahn Associates (Detroit) analyzed these tests and as a result urged special consideration for this type of construction in regions subject to earthquake shock, tornadoes and hurricanes.

Thermo - Con cellular concrete construction lends itself to high-speed, mass-production of buildings at low cost. However, it provides qualities and living conditions not found in the most expensive conventional construction. For example, Thermo - Con cellular concrete buildings give a high degree of insulation against heat or cold. They are also fire-proof, vermin-proof, rot-proof, dust-proof, moisture-resistant and sound-deadening. Thermo-Con cellular concrete structures are durable buildings, economical not only to build but also to maintain.

PHYSICAL PROPERTIES AND MATERIAL CONSTANTS

DENSITY - 45 to 50 pounds per cubic foot
Average compressive strength of cylinders at 28 days - 500 pounds per square inch
Average modulus of elasticity - 269,700 pounds per square inch
Shrinkage - .0058 inches per inch, maximum
Coefficient of Thermal Expansion - 7.0×10^{-6} inches per inch per degree F.
Average ultimate tensile strength in bending after 28 days - 33 pounds per square inch
Average ultimate diagonal tensile strength after 28 days - 33 pounds per square inch
Average ultimate pullout strength in bond after 28 days - 153 pounds per square inch

ALLOWABLE STRESSES are taken as a percentage of the minimum specified compressive strength in accordance with the A. C. I. Code. That is, 45% for compression, 2% in shear without web reinforcement, 6% in shear with web reinforcement and 5% in bond. The minimum specified ultimate compressive strength is taken at 400 pounds per square inch because of the fact that the tests of cylinders reflect less uniformity than the tests of full size sections.

THE DESIGN METHOD for Thermo-Con cellular concrete is identical to that for concrete, as outlined for instance, in the reinforced Concrete Design Handbook, published by the American Concrete Institute.

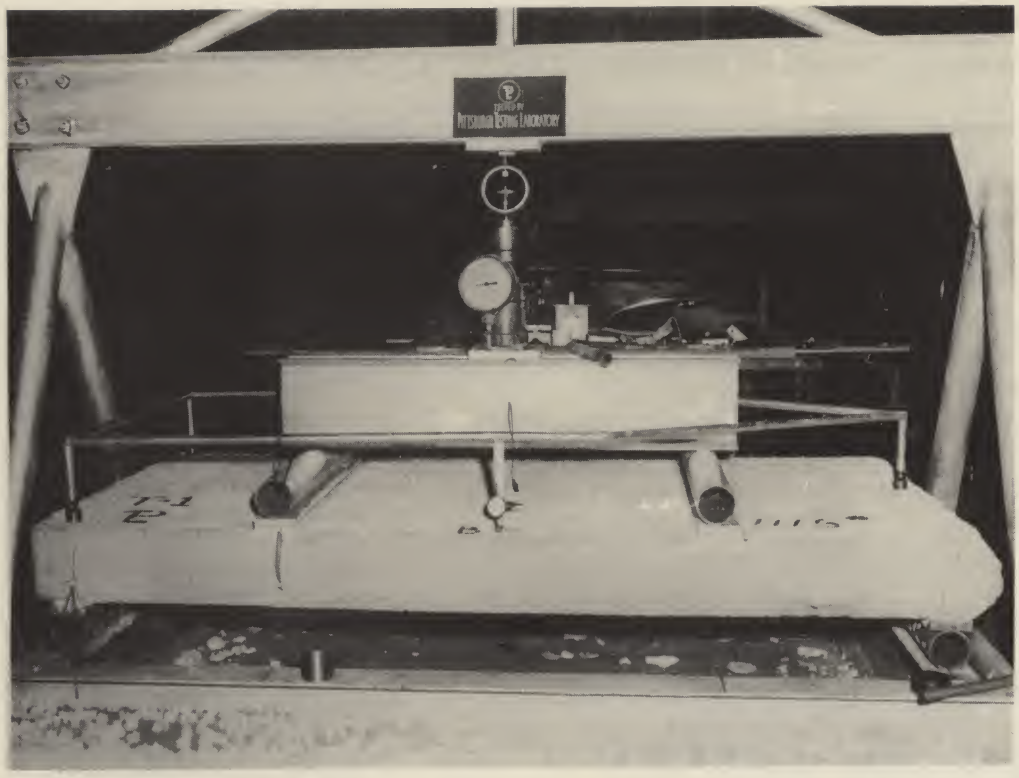
RECOMMENDED FACTORS FOR CALCULATIONS

fc	Extreme fiber stress in bending	180 p.s.i.
v	Without web reinforcement	8 "
v	With properly designed web reinforcement	24 "
U	Bond	20 "
fc	Walls - compressive stress $\frac{h}{t}$ = 12 or less	90 "
fc	Direct Bearing -	112 "
n		120 "

THERMAL PROPERTIES

K = 1.4 B.T.U. per hour, per square foot, per inch thickness, per degree F.

U for 6" Thermo-Con Cellular Concrete wall	=	.197
U for 8" Thermo-Con Cellular Concrete wall	=	.154
U for 10" Thermo-Con Cellular Concrete wall	=	.126
U for 12" Thermo-Con Cellular Concrete wall	=	.107



TRANSVERSE LOADING TEST - Pressure is applied at quarter points through beam from calibrated jack. Proving ring above jack is used as double check on accuracy. Average total load at failure: 10' span - 20,890 lbs.; 12' span - 15,868 lbs.; 14' span - 14,237 lbs.

IMPACT TEST - 60 lb. bag dropped from 10 ft. failed to destroy specimen.

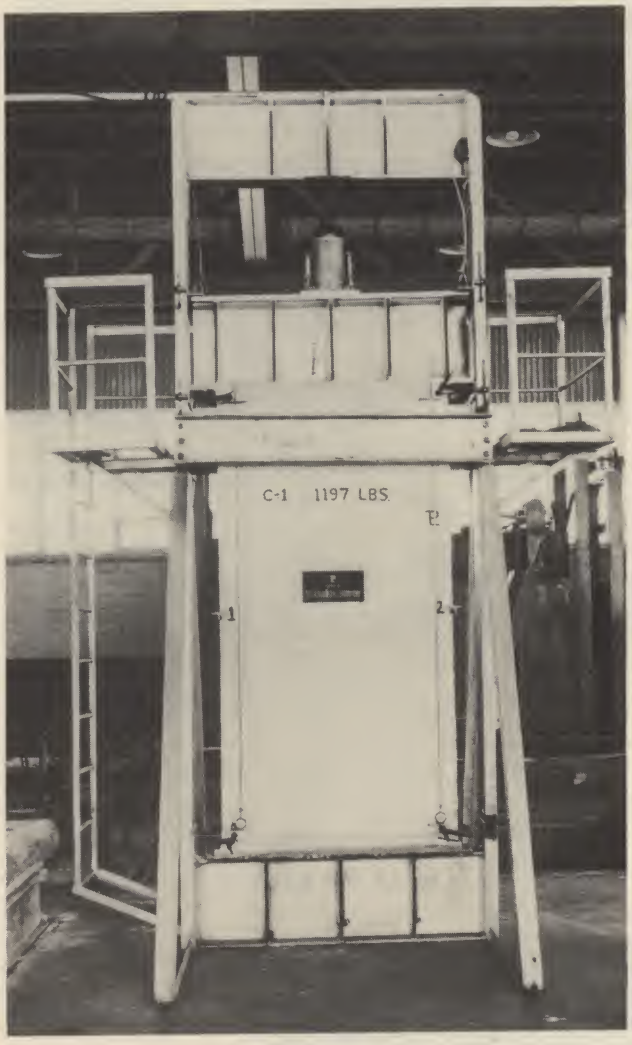
TABLE OF SAFE LIVE LOADS

For Thermo-Con cellular concrete slabs simply supported $M = \frac{wl^2}{8}$ and reinforced with 4" x 4" No. 6/6 electrically welded wire mesh. fs = 20,000 p.s.i.; fc = 180 p.s.i.; v = 8 p.s.i.

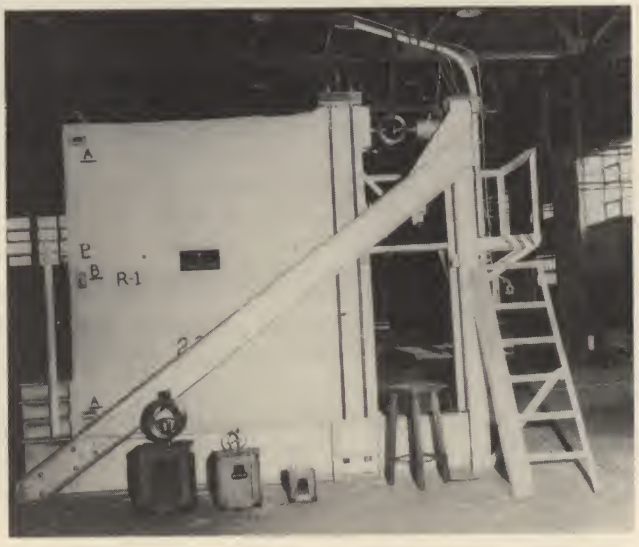
SPAN IN FEET	SLAB THICKNESS IN INCHES			
	6"	8"	10"	12"
5	132	182	246	307
6	106	155	198	247
7	88	128	164	205
8	74	108	138	173
9	63	93	118	149
10	54	80(1)	103	130
11	42	70	90	113
12	32	62(2)	79	100
13	24	48	70	89
14		37(3)	62	79
15		28	55	71
16		21	49(4)	63
17			44	57
18			38	51
19			30	42
20			23	33
21				26
No. of Layers of Mesh	2	2	3	3
Weight of Slab pounds/sq.ft.	23.6	31.5	40	47.3

In the table above only dead weight of slab is deducted. Floor finish, roofing, etc., should be deducted from given loads to obtain true live loads. Values above heavy line are governed by shear.

(1) Actual average of 5 tests	522 pounds/sq. ft.	Factor of Safety	4.68
(2) " " " " "	331 " " "	" " "	3.54
(3) " " " " "	254 " " "	" " "	3.71
(4) " " " " "	387 " " "	" " "	4.35



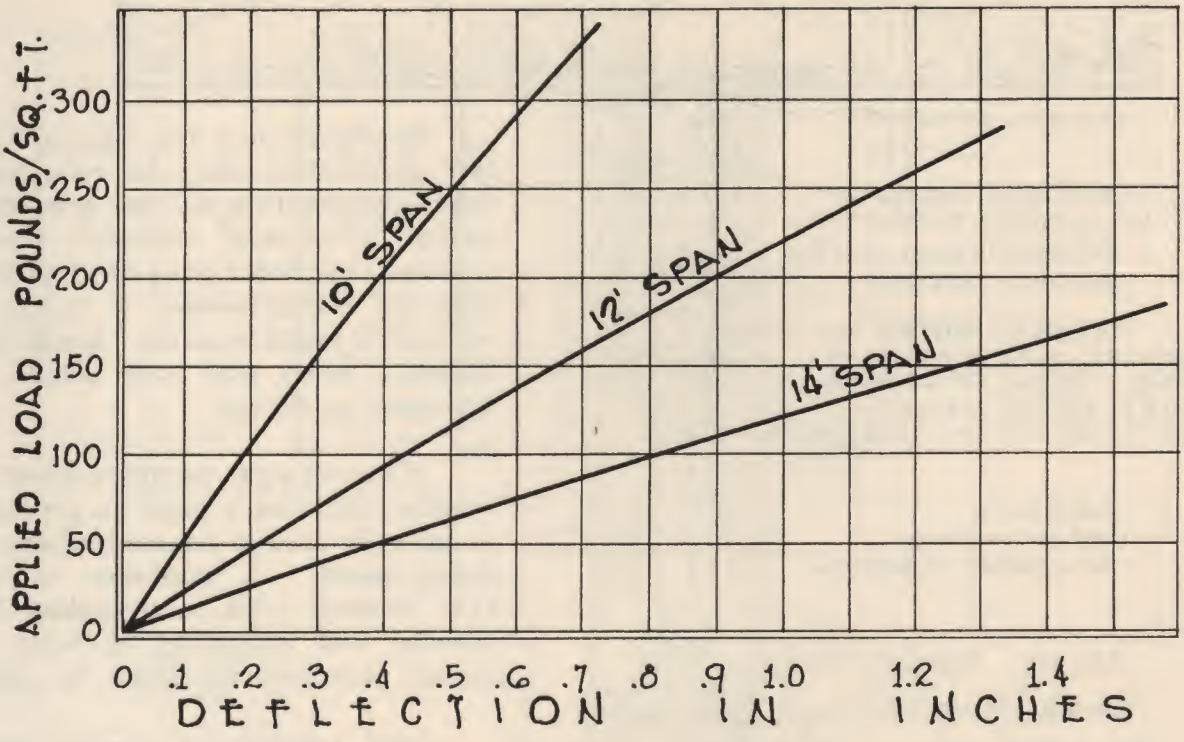
COMPRESSION OR VERTICAL LOAD TEST - Pressure is applied with hydraulic jack. Compression is read on gages at bottom of panel. Deflection is read on mirror gages at corner. Average of 3 tests - 112,000 lbs.



RACKING TEST - Load is applied with calibrated jack at upper right in series with proving ring. Specimens are grouted with plaster paris at pressure areas. Average of the tests - 62,000 lbs.

DEFLECTION CURVES

This information obtained during transverse bending tests conducted in accordance with the Bureau of Standards BMS-2. Tests witnessed by Pittsburgh Testing Laboratories and the representatives of FHA. All slabs were 8" thick and reinforced with 2 layers 4" x 4" x 6/6 mesh.

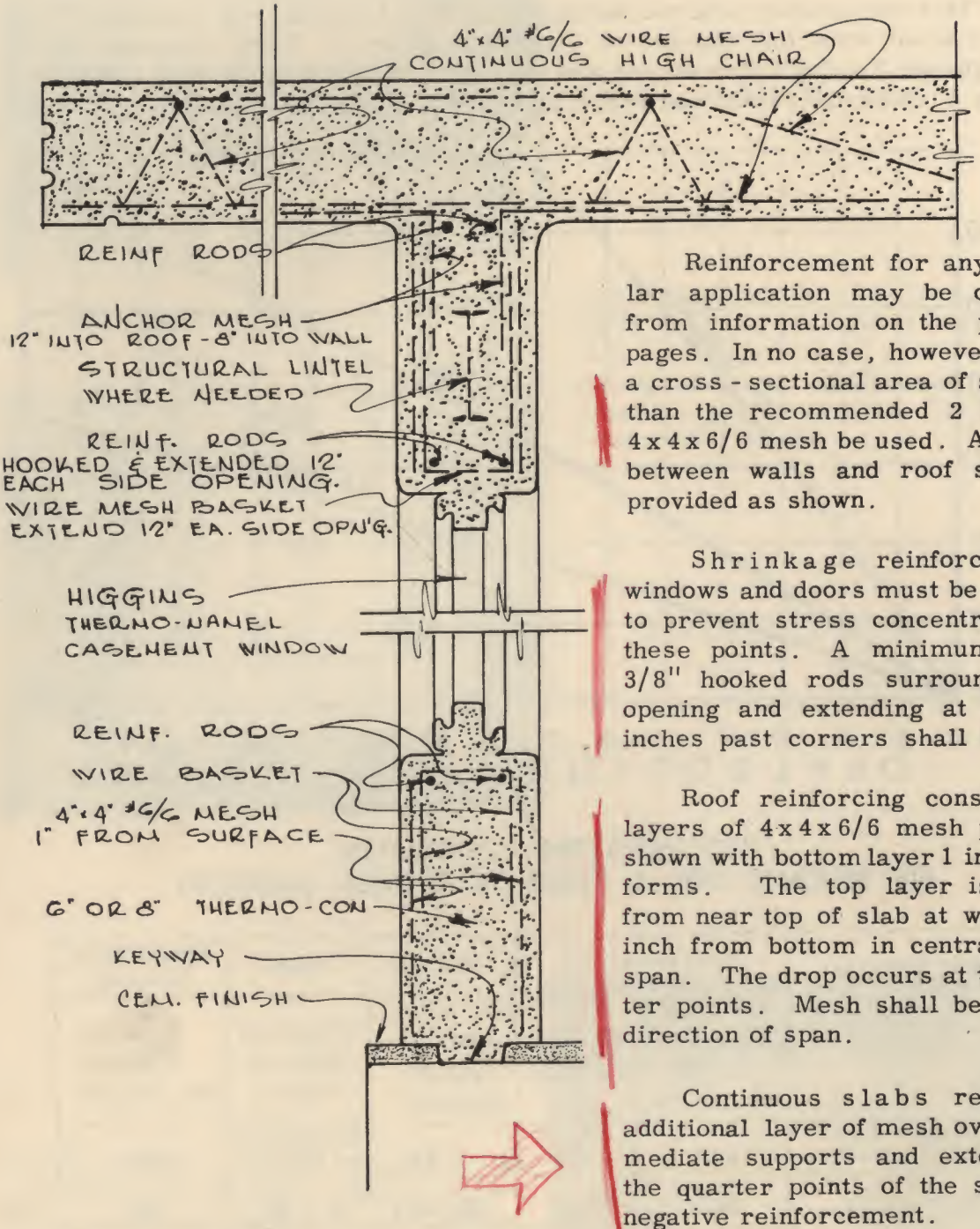


COMPARATIVE STRENGTHS OF THERMO-CON & COMMONLY USED MASONRY

Wall Material (all Walls 8" Thick)	Compression		Racking	Impact	Transverse Bending
	Average Ultimate Stress lbs./sq.in.	f'c wall / f'c unit	Horizontal Load at Failure Kips/ft.	Height of Drop at Failure	Load at Failure lbs./sq.ft.
Thermo-Con Cellular Concrete	300	.75	7.75	No failure at 10 feet	600*
Medium Brick	625	.44	No test	3' - 0"	52
Clay Tile (on side)	275	.32	3.74	2' - 6"	70
Concrete Block	420	.55	3.18	1' - 6"	35

* This figure was necessarily calculated to form a comparison. Other materials were tested on 7' - 6" span, while the shortest used for properly reinforced Thermo-Con cellular concrete was 10 feet. Even on 10' span, Thermo-Con cellular concrete carried 522 pounds per square foot.

REINFORCEMENT



FOUNDATION WALL & FTG. FOLLOW STANDARD PRACTICE

Reinforcement for any particular application may be calculated from information on the preceding pages. In no case, however, should a cross-sectional area of steel less than the recommended 2 layers of 4x4x6/6 mesh be used. Anchorage between walls and roof should be provided as shown.

Shrinkage reinforcement at windows and doors must be provided to prevent stress concentrations at these points. A minimum of two 3/8" hooked rods surrounding the opening and extending at least 12 inches past corners shall be used.

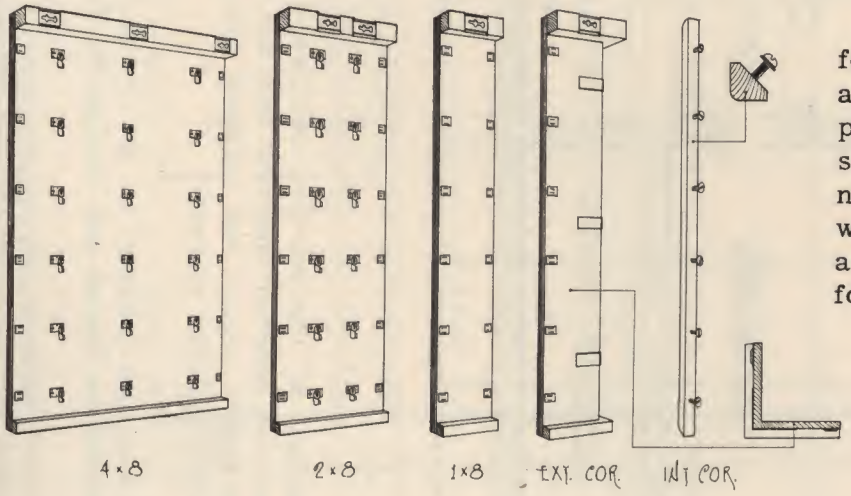
Roof reinforcing consists of 2 layers of 4x4x6/6 mesh placed as shown with bottom layer 1 inch above forms. The top layer is draped from near top of slab at walls to 1 inch from bottom in central part of span. The drop occurs at the quarter points. Mesh shall be layed in direction of span.

Continuous slabs require an additional layer of mesh over intermediate supports and extending to the quarter points of the spans for negative reinforcement.

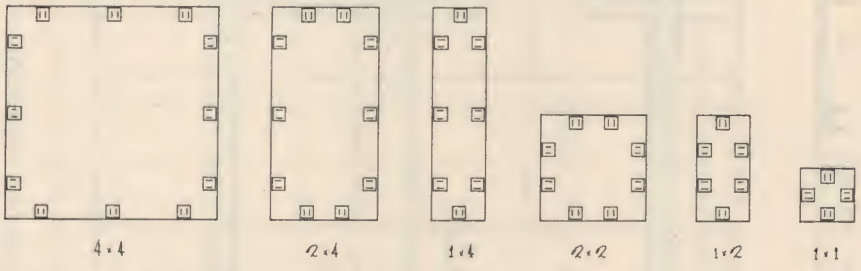
The use of a keyway approximately 1-5/8" x 3-5/8" between foundation and wall is considered adequate anchorage without the use of dowels. Dowels placed at this point will seriously hamper the erection of forms.

DESCRIPTION OF THERMO-CON CELLULAR CONCRETE FORMS

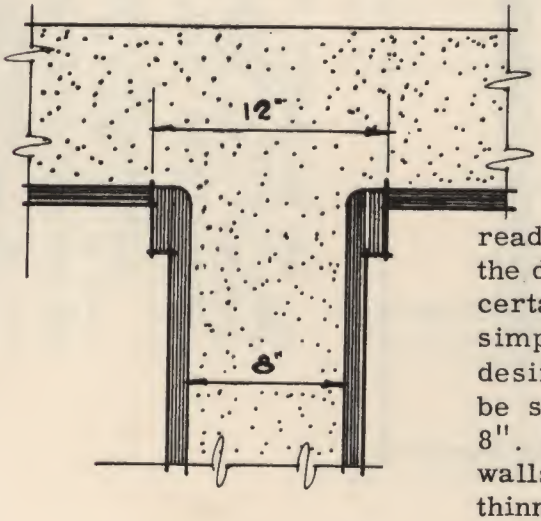
Thermo-Con forms are modular, plastic faced, marine bonded wood forms developed primarily for use with this construction method. The main features are ease and rapidity of erection and stripping, plus reusability on many and varied types of structures.



The basic wall forms, 4' x 8', are assembled in pairs, providing a rigid section requiring neither bracing nor walers. The 2' x 8' and 1' x 8' wall forms provide maximum flexibility of design.

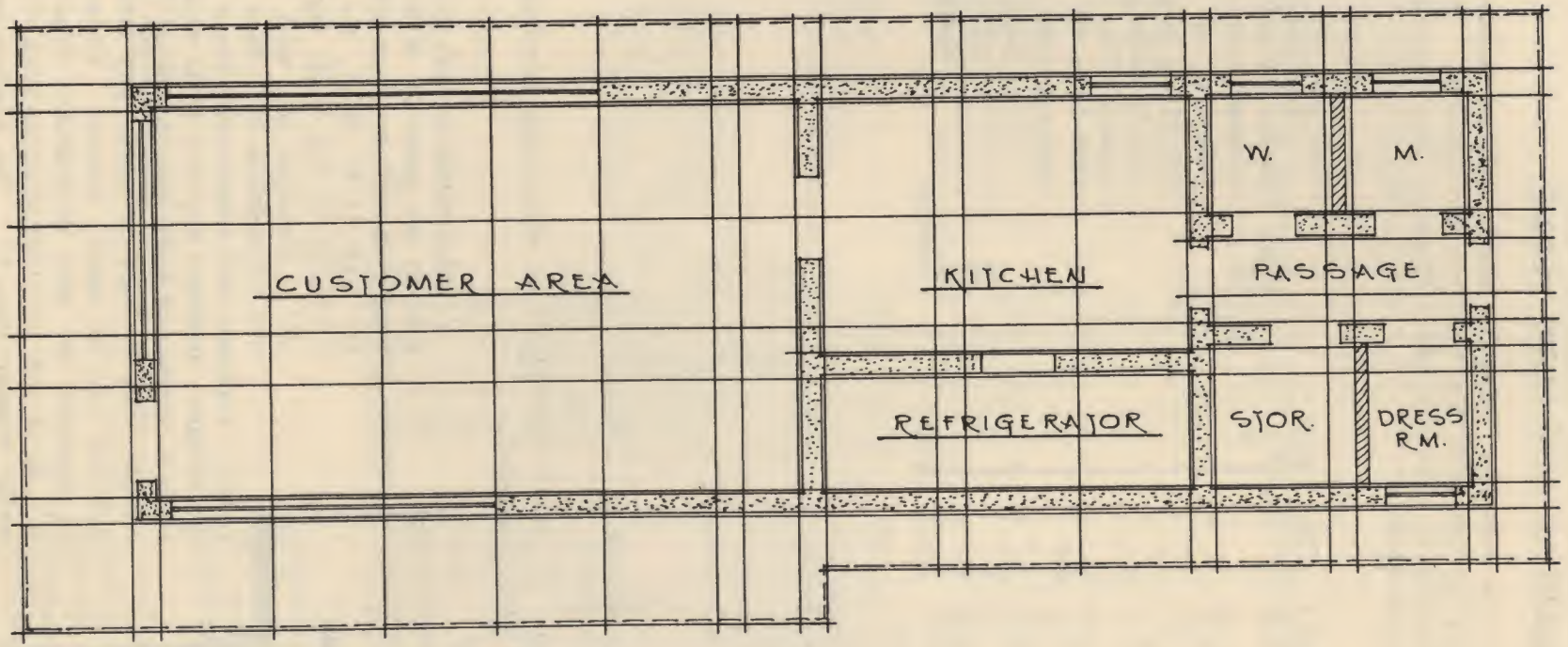


Ceiling forms are provided in sizes to carry out the module set by the walls. Attachment of all forms to each other is by means of metal connectors of which only three types are used and are applied with a hammer.



Illustrated at left is a section at the junction of wall and roof. It will be seen although the wall is 8" thick, the space occupied by the wall forms is 12". Because all wall forms are in modula of 1 foot, it is readily apparent that when using these forms the distance between any two walls must be a certain number of feet, plus 4 inches. If this simple rule is kept in mind, any structure desired may be easily formed. Forms can be supplied for wall thicknesses other than 8". It is not considered economical to form walls thinner than 6". We recommend that thinner non bearing walls be built of conventional materials.

· FORM · LAYOUT ·



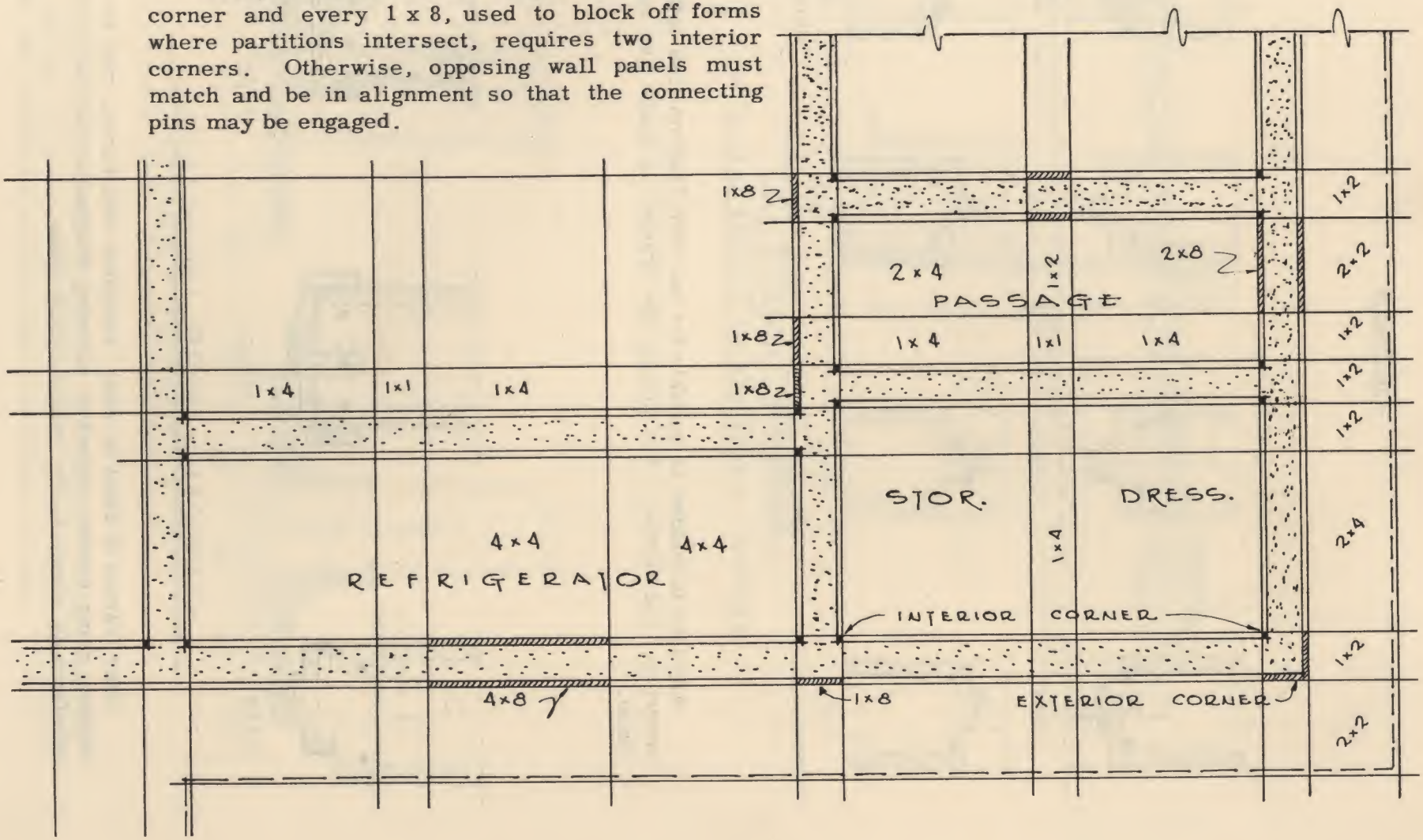
The layout above shows a typical roadside restaurant of Thermo-Con cellular concrete. Note the large walk-in refrigerator using the Thermo-Con cellular concrete wall for primary insulation. The partitions between the ladies' and men's rooms and between storage and dressing rooms are of material other than Thermo-Con cellular concrete.

This plan illustrates the method of layout which must be followed in the design. If the form grid is shown on the floor plan, it not only simplifies layout and design but furnishes all information to the builder for form erection.

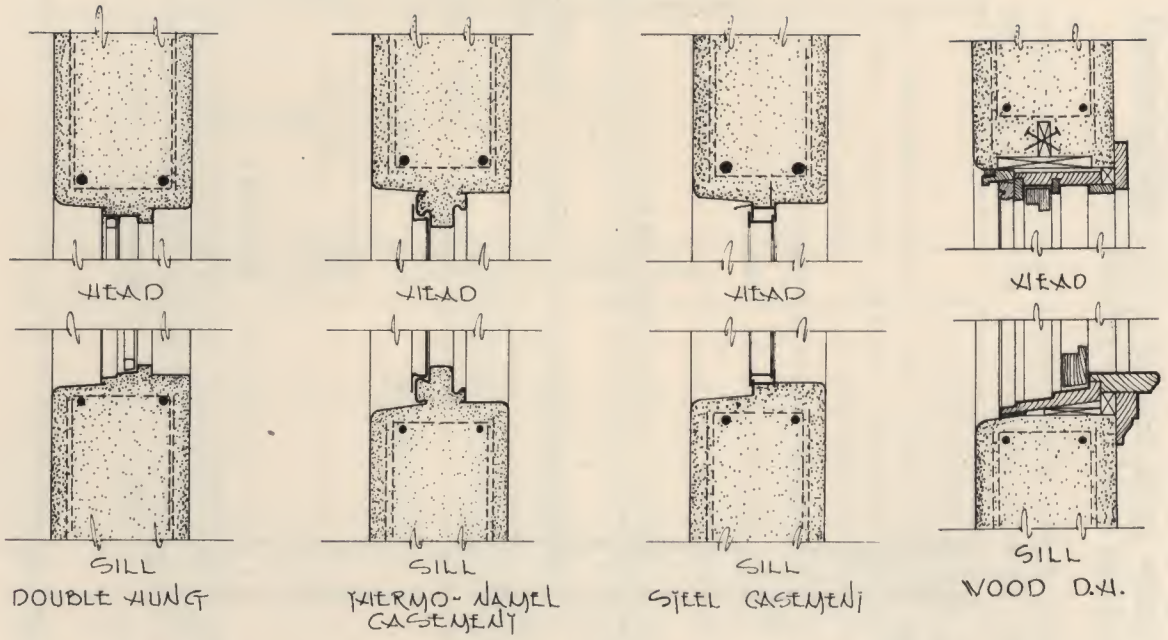
The enlarged section on page opposite is intended to illustrate, to those unfamiliar with Thermo-Con forms, the use and position of the various pieces in assembly. Windows and doors may be set in the forms wherever desired.

The refrigerator space is required to be 3' - 4" in width, which means the use of a 2-foot and a 1-foot panel. In the kitchen and customer area, however, 4-foot forms can be used to good advantage, reducing the number of pieces to be handled. This change cannot occur inside the wall, but must start with the first ceiling panel on the kitchen side.

Every exterior corner requires an interior corner and every 1 x 8, used to block off forms where partitions intersect, requires two interior corners. Otherwise, opposing wall panels must match and be in alignment so that the connecting pins may be engaged.

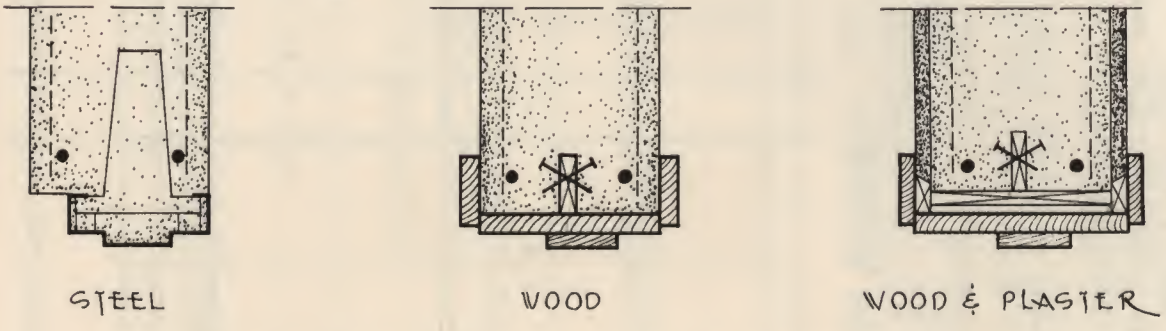


DETAILS



TYPICAL WINDOW DETAILS

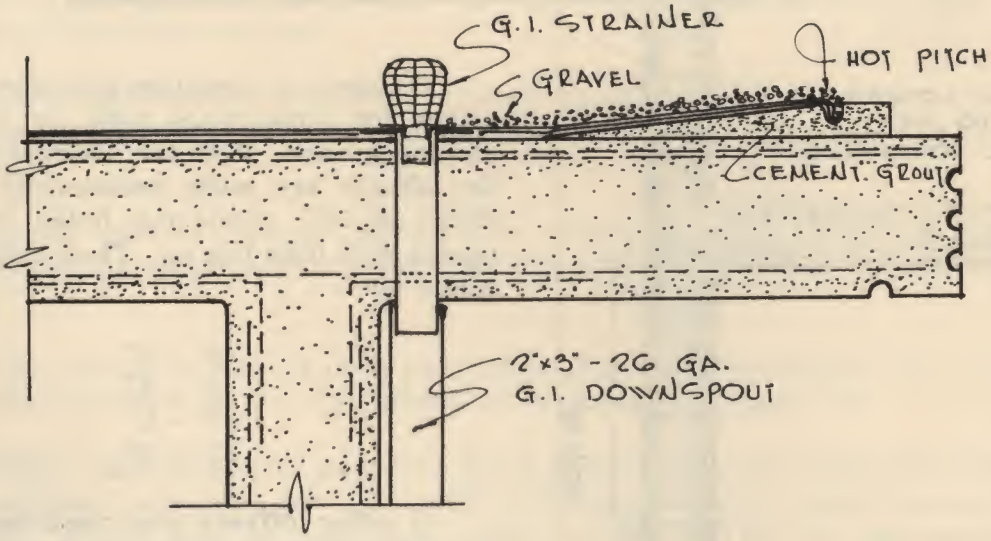
Any type of window is suitable for use with Thermo-Con cellular concrete, and formers for casting the frames in place are easily made.



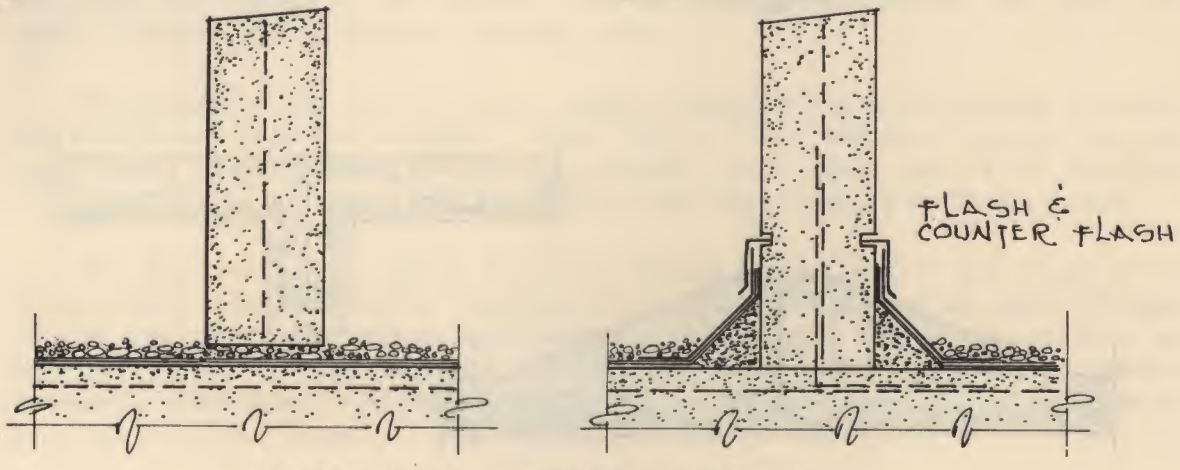
TYPICAL DOOR DETAILS

Door frames of steel or wood, complete with bucks, may be cast in place using former pieces or allowing finished casing to act as its own form as shown in the center detail above.

DETAILS



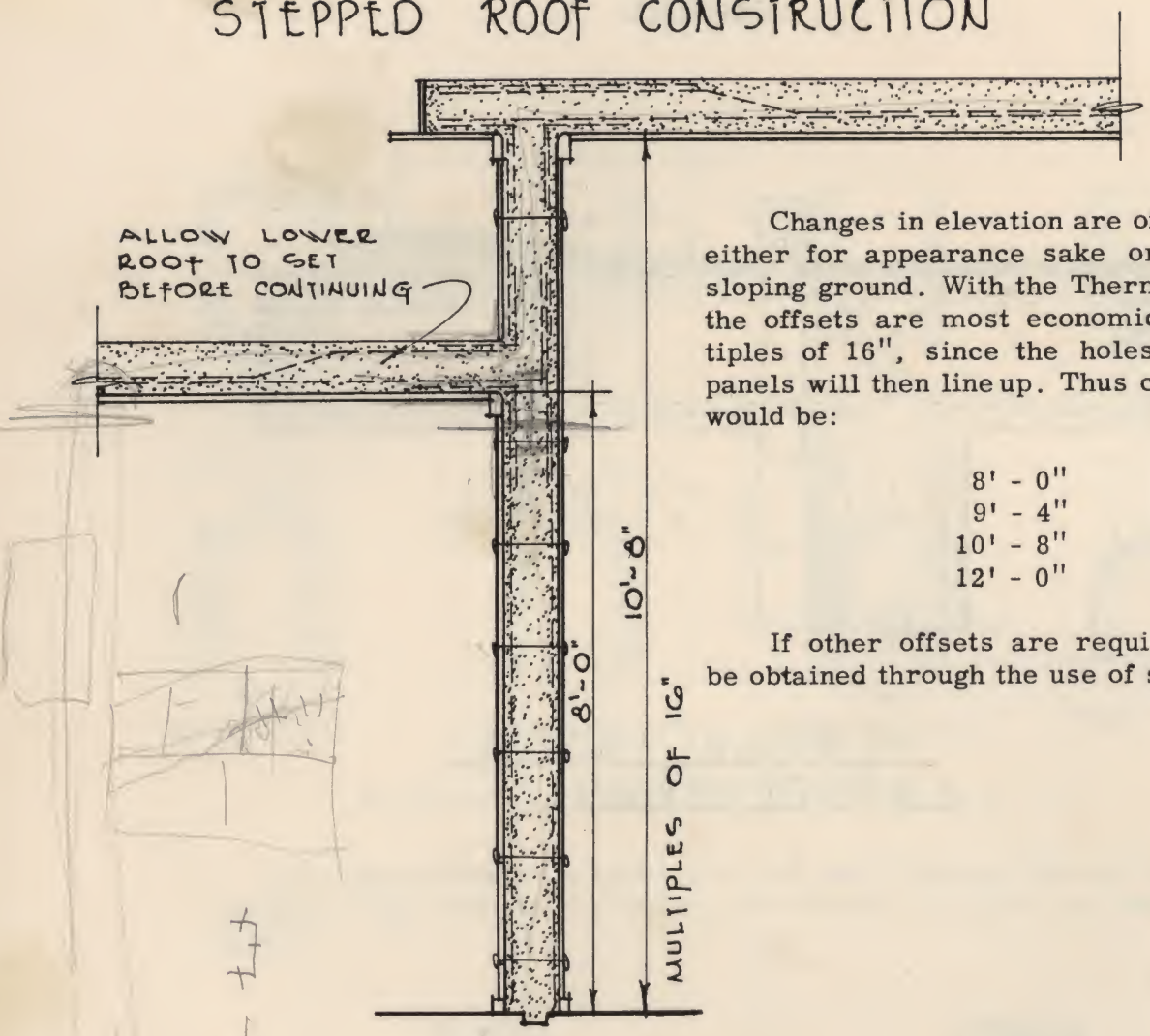
TYPICAL FACIA & ROOF DRAIN



TYPICAL PARAPETS

The left hand detail is simpler and cheaper, but bear in mind that roofing materials may deteriorate and need repair eventually, so that wall should be sectionalized to facilitate removal.

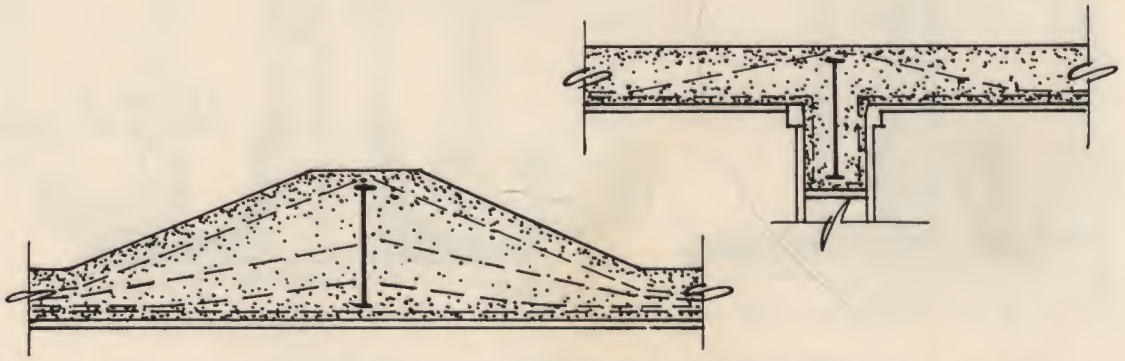
STEPPED ROOF CONSTRUCTION



Changes in elevation are often desirable either for appearance sake or economy on sloping ground. With the Thermo-Con forms the offsets are most economical if in multiples of 16", since the holes in opposing panels will then line up. Thus ceiling heights would be:

8' - 0"
9' - 4"
10' - 8"
12' - 0"

If other offsets are required they may be obtained through the use of special forms.



LONG SPANS

Deep sections of beams or girders may be encased in Thermo-Con cellular concrete, either above or below the slab, as indicated.

SPECIFICATIONS FOR THERMO-CON CELLULAR CONCRETE

All Thermo-Con cellular concrete construction is to be supervised and inspected by qualified personnel, with special attention to the proper mixing and pouring of the material.

All cement used is to be an approved brand of Portland cement. The contractor shall secure the architect's approval of the brand which he proposes to use.

Water used in mixing Thermo-Con cellular concrete shall be clean and free from injurious material such as oil, acid, salt, alkali, organic matter, etc.*

The mixing of the cement and water with the ingredients "X", "Y", and "Z" shall conform to the regulations as set forth by Higgins Inc.

Walls shall be poured at a rate not to exceed 16 inches (expanded Thermo-Con cellular concrete) per lift. Slab pouring shall be as continuous as practicable. Joints will be permitted parallel to the span but not perpendicular to the span.

Thermo-Con forms shall be erected in accordance with the instructions as issued by Higgins, Inc. Care shall be taken with special forming to see that it is water tight and will not shift during pouring.

Before pouring, forms shall be inspected for water and trash accumulations and drained or cleaned if necessary.

Special attention shall be given to see that all hollow lintels are poured full and that expansion of Thermo-Con cellular concrete does not block off ends of long banks of window, causing voids.

Screeding of the roof or floor shall proceed along with pouring to obtain the smoothest possible surface. After Thermo-Con cellular concrete has set sufficiently hard to walk on without indentation, a grout coat of one part cement to three parts sand shall be worked over slab to bring to finish grade.

All Thermo-Con cellular concrete surfaces shall be free and clean of all loose scaly material before the finish is applied. This can be accomplished by the use of sand blasting equipment or by hand with saw-tooth scrapers or wire brushes. If hand methods are used the work shall be carried on simultaneously with form removal. Sandblasting may be done at any time prior to application of the finish.

After stripping, all holes shall be plugged, all voids and rough surfaces pointed up.

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* Thermo-Con cellular concrete has been mixed and cast using seawater, muddy and brackish water with good results, however no information is available at present on the lasting qualities of such Thermo-Con cellular concrete or the effect of such water on the reinforcing.

FINISHING

NO FINISH WHATSOEVER SHALL BE APPLIED TO THERMO-CON CELLULAR CONCRETE UNTIL IT HAS AGED (after stripping forms) A MINIMUM OF TWO WEEKS IN WARM, DRY WEATHER. In cool or damp weather this interval shall be increased.

SPECIFICATIONS FOR THERMO-SEAL FINISH

THERMO-SEAL is a cement base paint with exceptional waterproofing and weathering qualities, which may be obtained from Higgins, Inc. Its use is strongly recommended for all exterior Thermo-Con cellular concrete finishing. Thermo-Seal shall not be applied at temperatures under 40 degrees, F.

MIXING shall be in strict accordance with instructions accompanying the material. Texture coats shall contain not more than 3 parts sand to 1 part Thermo-Seal powder, by volume. Finish coats shall be 3 quarts water to 8 pounds Thermo-Seal powder.

THE TEXTURE COAT of Thermo-Seal shall be applied to both exterior and interior surfaces by brush (trowel) (dash) (roll). Coarseness of texture shall be determined by sample areas to be approved by the architect (builder) (owner). As application progresses the texture coat shall be hardened by water curing and the finish coat shall not be applied until texture coat has been approved for uniformity and hardness by the architect (builder) (owner).

CURING consists of keeping finish damp for a minimum of 2 hours during the first 24 hours after application. Curing may be started as soon as material is hard enough to resist mist spraying and is complete when it is hard and firm and does not rub off on the fingers.

THE FINISH COAT shall be applied by brush (spray). Water curing shall progress with work to obtain a hard, dense surface. All exterior surfaces are to be finished with Thermo-Seal. All interior surfaces are to be finished with Thermo-Seal (water emulsion paint) (alkali sealer followed by oil paint).

NOTE: It must be stressed that the life and hardness of Thermo-Seal depends on proper curing.

OTHER FINISHES

Sand or textured finishes applicable to cement or masonry may be used with Thermo-Con without the necessity of heavy ground coats.

If a hard, smooth plaster finish is desired, it is recommended that it be applied over rib lath in the usual manner.

METRIC CONVERSIONS

of

COMMONLY USED DIMENSIONS WITH

THE THERMO-CON SYSTEM

FORM SIZES

Feet	Meters
4 x 8	1.219 x 2.438
2 x 8	.610 x 2.438
1 x 8	.305 x 2.438
4 x 4	1.219 x 1.219
2 x 4	.610 x 1.219
1 x 4	.305 x 1.219
2 x 2	..610 x .610
1 x 2	.305 x .610
1 x 1	.305 x .305

1 inch = .025 meters

4 inches = .101 meters

6 inches = .152 meters

8 inches = .203 meters

1 Meter = 3.281 ft.

1 Sq. Meter = 10.76 sq. ft.

1 Cu. Meter = 35.31 cu. ft.

.566 Cu. Meters = 20 cu. ft.

ROOM DIMENSIONS

Feet	Meters
2' - 4"	.7112
3' - 4"	1.016
4' - 4"	1.321
5' - 4"	1.626
6' - 4"	1.931
7' - 4"	2.236
8' - 4"	2.540
9' - 4"	2.845
10' - 4"	3.150
11' - 4"	3.454
12' - 4"	3.759
13' - 4"	4.064
14' - 4"	4.369
15' - 4"	4.674
16' - 4"	4.979
17' - 4"	5.284
18' - 4"	5.588
19' - 4"	5.893
20' - 4"	6.198

NOTES

Thermo-Con *Cellular Concrete System*

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New Orleans 22, La.